

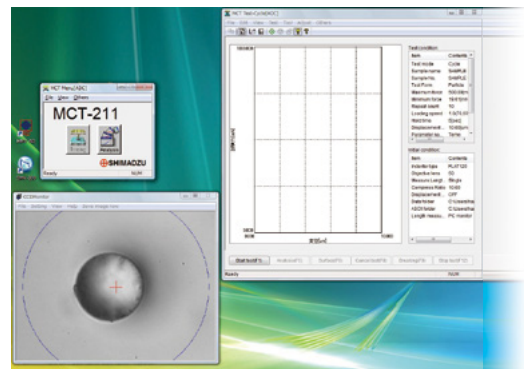
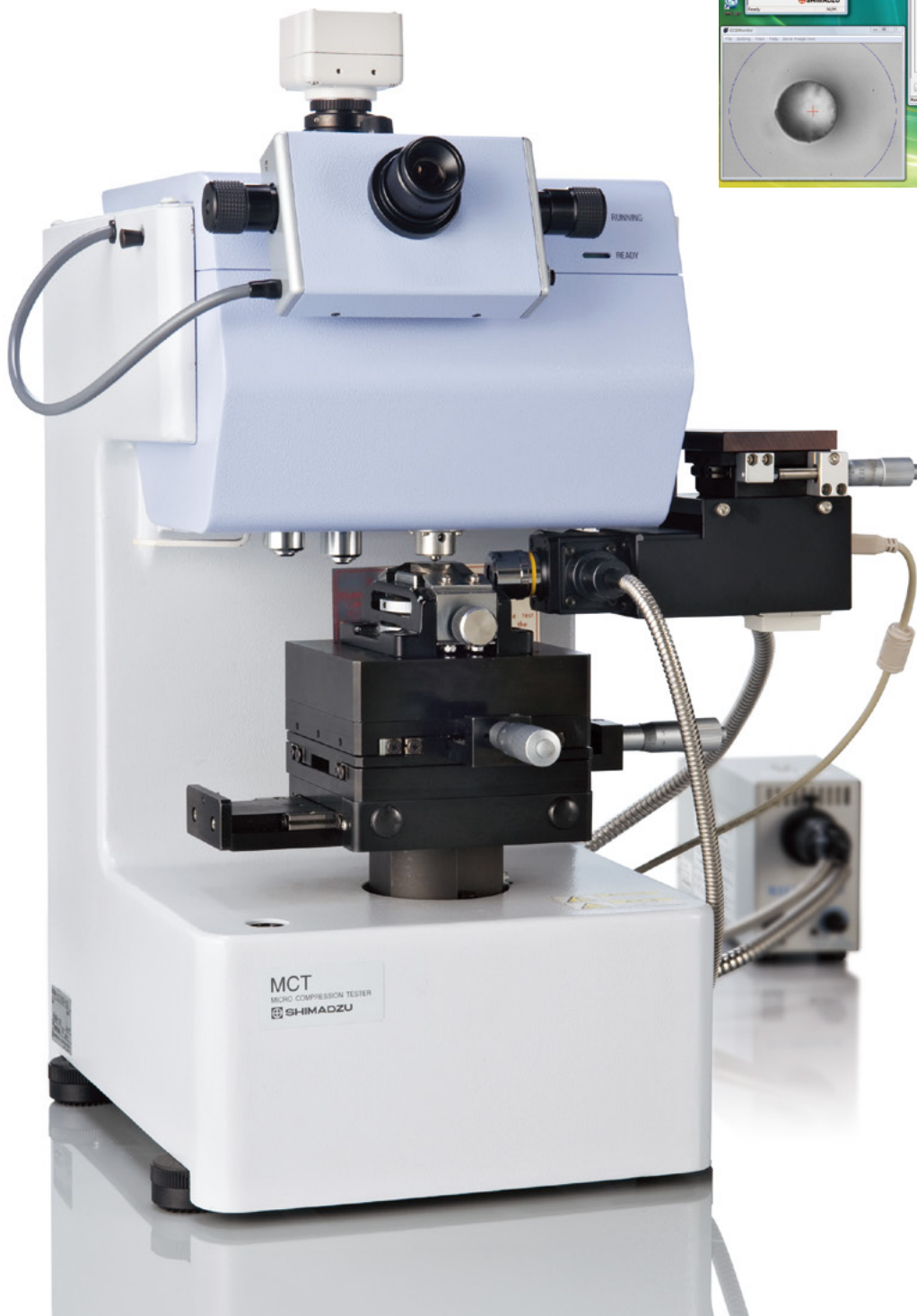
Micro Compression Testing Machine

MCT Series



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Evaluates Compression Strength of Various of Micro Specimens

The Shimadzu micro compression testers MCT Series evaluate the strength of micro components, micro particles generated in powder processing and fine fibers used in new materials.

As production of spherical micro powder particles with diameters from several microns to several 100 μm becomes possible with the advancements in metal and ceramic powder manufacturing technologies, it has become necessary to evaluate their characteristics. Fine fibers used in composite materials, as well as various other micro materials, also need to be evaluated for their compression characteristics.

The Shimadzu MCT Series is just the right micro compression tester to meet strength-evaluation needs in the fields of micro particles and fine fibers.



Evaluates the compression strength of micro substances.

- Variety of micro components
- Ceramic particles
- Fine metallic powder
- Resin particles
- Pigments
- Food source powders
- Pharmaceuticals (micro capsules)
- Fine fibers

Powders, which easily condense and lose fluidity due to their lack of momentum and also disperse easily, are extremely difficult to handle. Particle size enlargement to increase the apparent momentum is a common method to combat this problem. The enlarged particles should not break apart during transportation but have to be easily decomposed to the original particles when, for example, mixed into polymer materials. In other words, they have to be processed to break under a specific load.

The MCT Series, capable of compression characteristics evaluation for each particle, is also ideal for the evaluation of enlarged particles.

A New-Concept Compression Testing Machine for Evaluating the Strength of Micro Materials

1. Micro Compression Displacement Measurement

To enable evaluation of compression characteristics of various micro materials, the MCT series provides models with two different resolution and measurement ranges:

- measurement range up to 100 μm and resolution of 0.001 μm .
- measurement range up to 10 μm and resolution of 0.0001 μm .

2. Wide Load Range

The MCT series is available in two different test forces: maximum test forces of 4903 mN and 1961 mN.

3. Highly Accurate Measurement

Test force are applied at an accuracy of $\pm 1\%$ of the set or displayed test force, whichever is greater.

4. Measurement of Specimen Dimension Provided as Standard

The specimen dimension measurement function that uses an overhead image (provided as standard) enables determination of the geometrical mean diameter and length of the specimen.

5. Length Measurement on PC Screen and Saving of Images (optional)

Use the optional length measurement kit (color or monochrome) to display the overhead image on the PC screen to measure the length of the specimen.

The image can also be saved as digital data.

6. Display of Specimen Images During Compression (optional)

An image captured in side observation during compression can be displayed (the optional side observation kit is required).

7. Testing also Possible under High-Temperature Conditions (optional system)

Testing can be performed in temperature conditions ranging from 50 to 250°C.

Main Testing Sequence

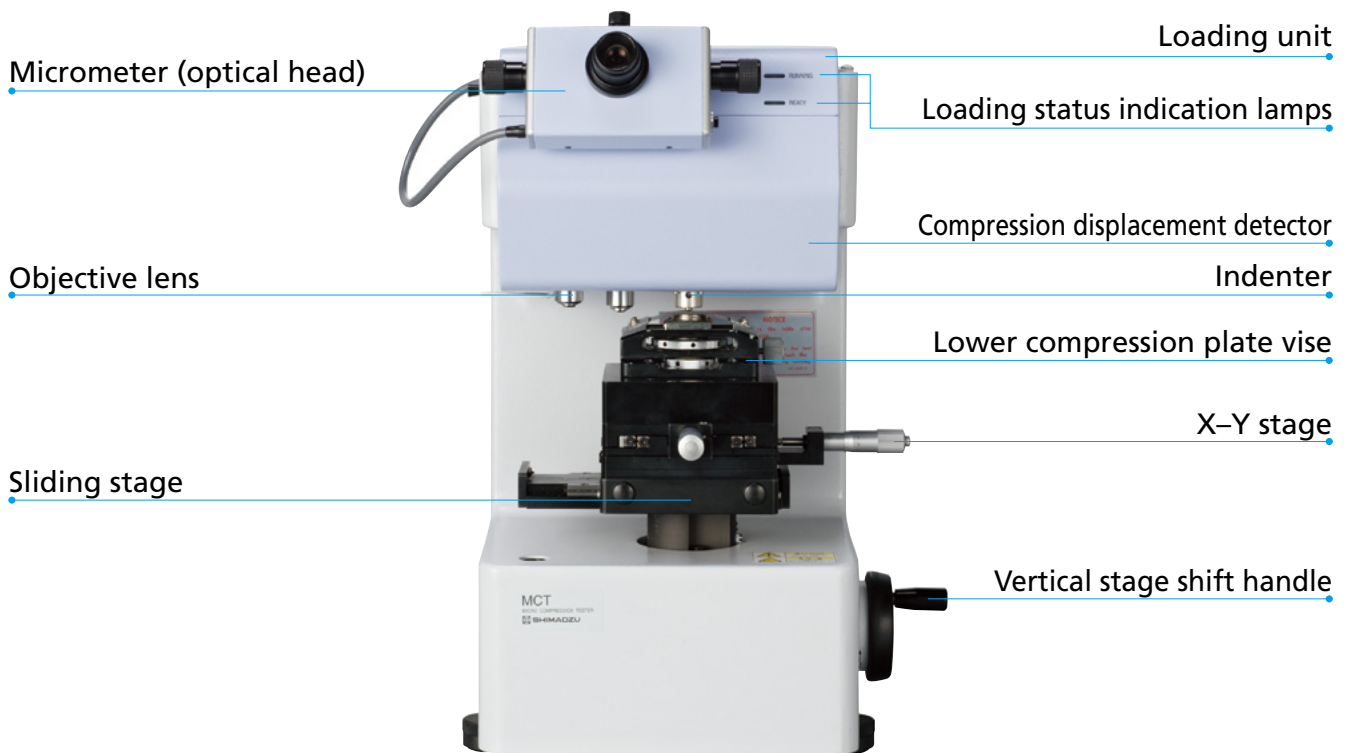
1. Setting test parameters

2. Specimen observation with a microscope and dimensional measurement (when necessary)

3. Loading

4. Analysis

A Design with Simplicity in Mind



Micrometer (optical head)

This unit measures the size of the specimen. The specimen is sandwiched by two indicators to enable measurement up to 200 μm at an increment of 0.1 μm (when the $\times 50$ objective lens is used). The measured dimension is displayed on the PC screen where it can be further processed to calculate and display the strength of the specimen.

Objective Lenses

The standard $\times 50$ and optional $\times 100$ lenses are available for length measurement. For observation, the standard $\times 10$ and optional $\times 20$ lenses are available.

Sliding Stage

The test point is selected with the micrometer and that point is shifted to just below the indenter.

The click-stop mechanism ensures accurate positioning of the specimen.

Vertical Stage Shift Handle

The stage is smoothly shifted with this single handle.

Loading Unit

The test force range is from 9.8 to 4903 mN or 1961 mN.

The electromagnetic method ensures highly precise loading.

Loading Status Indication Lamps

The red lamp (RUNNING) is lit during loading. The green lamp (READY) indicates that the operator can touch the indenter with safety.

Compression Displacement Detector

A detector is configured in the upper section of the indenter to accurately measure the compression displacement.

Indenters

The following indenters are available.

- 50 μm diameter flat indenter
 - 500 μm diameter flat indenter (optional)
 - 115° triangular pyramid indenter (optional)
- (The triangular pyramid indenter is used for tests where the specimen is larger than 500 μm and cannot be broken at a test load of 4903 mN.)

Lower Compression Plate Vise

This ergonomically constructed vise firmly secures the lower compression plate.

X-Y Stage

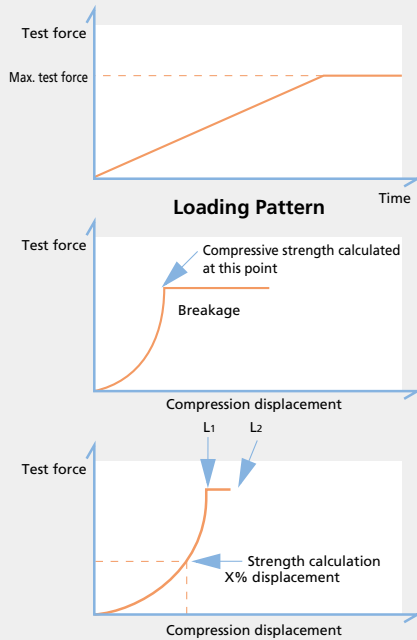
This stage can be shifted over a range of 25 mm in the X-Y directions. It can be moved in increments of 0.01 mm with the standard micrometer. A digital micrometer is also available as an option.

Testing of Diverse Physical Properties

[Choose test modes that suit the purpose of the test.]

Compression Test

When a particle or fiber is selected as the specimen, force increased to the set point and the compressive strength is determined when the specimen breaks, or if the specimen does not break, the strength at time of specified deformation is determined. For other types of specimens, the test ends at the preset force point.



Compressive strength

Compressive strength is calculated at the breaking point using two parameters force at breaking point and diameter of the particle.

- For particles : $Cs (Cx) \text{ or } St (Sx) = a \times P / (\pi \times d \times d)$
- Cs : Strength (MPa) $a = 2.48$
(JIS R 1639-5)
- Cx : Reference strength (MPa) $a = 2.48$
- St : Strength (MPa) $a = 2.8$
(the equation of Hiramatsu *et al.* (P.7 reference))
- Sx : Reference strength (MPa) $a = 2.8$
- P : Test force (N)
- d : Diameter of particle (mm)
- For fibers : $St (Sx) = 2P / (\pi \times L \times d)$
- St : Strength (MPa)
- Sx : Reference strength (MPa)
- P : Test force (N)
- d : Diameter of fiber (mm)
- L : Fiber length (mm)

Rate of Change

The rate of change is calculated from the displacements at the beginning (L_1) and the end (L_2) of the load-hold time.

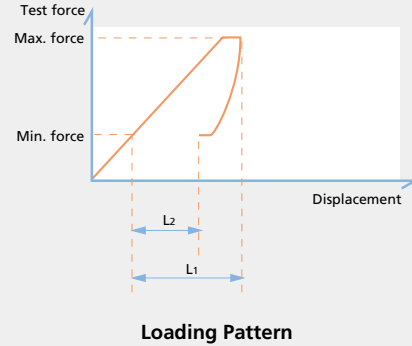
For particles and fibers: Rate of change $Cp = (L_2 - L_1) / d \times 100$

Other specimens : Variation $Dp = L_2 - L_1$

- Cp : Rate of change (%)
- Dp : Variation (μm)
- d : Diameter of particle or fiber (μm)
- L_1 : Displacement at the beginning of load-hold time (μm)
- L_2 : Displacement at the end of load-hold time (μm)

Load-unload Test

Test force is increased to the maximum force point and then decreased to the minimum force point.



For particles and fibers

$$\text{Compression rate } Cr = L_1/d \times 100$$

$$\text{Recovery rate } Rr = (L_1 - L_2)/d \times 100$$

Cr : Compression rate (%)

Rr : Recovery rate (%)

d : Diameter of particle or fiber (μm)

L_1 : Displacement 1 (μm)

L_2 : Displacement 2 (μm)

For other

$$\text{Compression amount } Cv = L_1$$

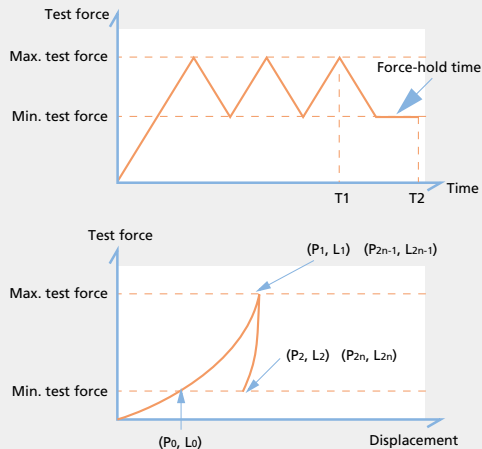
$$\text{Recovery amount } Rv = L_1 - L_2$$

Cv : Compression amount (μm)

Rv : Recovery amount (μm)

Cyclic Test

Test force is repeatedly increased and decreased up to 250 times to evaluate the property of the specimen under repeatedly applied force.



Loading Pattern

The rate or amount of compression and recovery are determined for each cycle.

For particle and fibers:

$$\text{At } n \text{ cycle compression rate } Cr = (L_{2n-1} - L_0)/d \times 100$$

$$\text{recovery rate } Rr = (L_{2n-1} - L_{2n})/d \times 100$$

Cr: Compression rate (%)

Rr: Recovery rate (%)

d : Diameter of particle or fiber (μm)

L₀: Displacement at the minimum test force during loading in first cycle (μm)

L_{2n-1}: Displacement at the maximum test force in n cycle (μm)

L_{2n} : Displacement at the end of unloading in n cycle (μm)

For other specimens:

$$\text{At } n \text{ cycle compression amount } Cv = L_{2n-1} - L_0$$

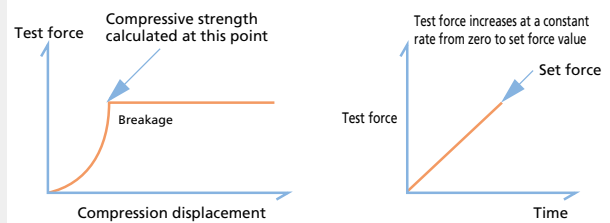
$$\text{recovery amount } Rv = L_{2n-1} - L_{2n}$$

Cv: Compression amount (μm)

Rv: Recovery amount (μm)

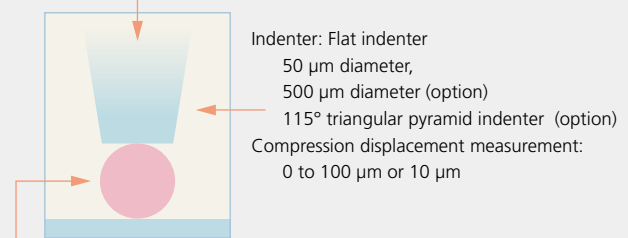
Measurement Principle

A test force at a constant augmented rate is applied to the specimen, secured between the upper compression rod (a 50 μm flat indenter provided as standard) and the lower compression plate. The amount of deformation of the specimen is then automatically measured. The test force can be set between 9.8 and 4903 mN, or between 9.8 and 1961 mN. Measurement is possible up to 100 μm or 10 μm at a resolution of 0.001 μm or 0.0001 μm . The pressure and amount of deformation during the specimen deformation are measured and recorded. This allows dynamic measurement of deformation characteristics of fine particles and provides a wealth of information. Moreover, specimens that include different size of particles can also be evaluated because specimen size can be measured using a microscope.



- A rapid increase in displacement shows that the specimen has been broken.
- The specimens mechanical strength (torsion strength) is determined from the force causing the rupture.

Force: 9.8 to 4903 mN or 1961 mN load using electromagnetic force



Specimen: Individual compression of 1 to 500 μm diameter particles possible. Compression of 1 to 500 μm diameter fibers possible. Diluting agent (alcohol, etc.) required in order to dilute specimen for separation.

Specimen sizing: Specimen size can be measured at an increment of 0.1 μm using an optical microscope.

● For particles

Mechanical strength acquired using JIS R 1639-5 *1

$$Cs = 2.48 \times \frac{P}{\pi d^2}$$

the equation of Hiramatsu *et al.* *2

$$St = 2.8 \times \frac{P}{\pi d^2}$$

Cs or St : Strength (MPa)

P : Force (N)

d : Particle diameter or fiber diameter (mm)

L : Fiber length (mm)

● For fibers

$$St = \frac{2P}{\pi dL}$$

Bibliography:

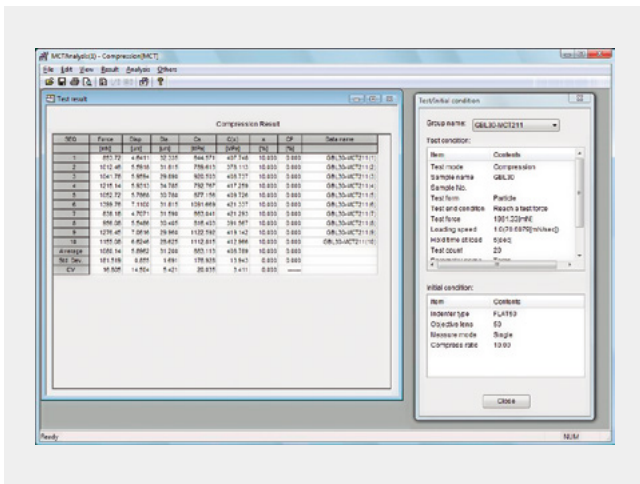
*1 Test methods of properties of fine ceramic granules Part 5: Compressive strength of a single granule

*2 Hiramatsu, Oka, Kiyama: *MMIJ Journal* Vol. 81 (1965)

Abundant Analysis Functions Aid Evaluation of Compression Characteristics [Examples of data processing]

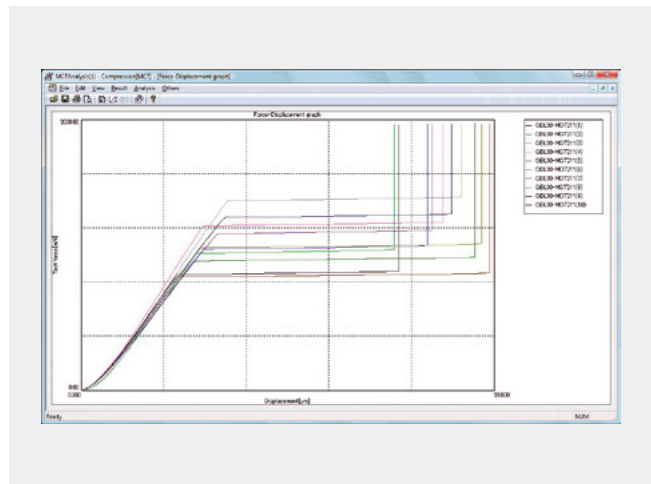
Display of Test Force, Displacement and Strength

Test results (test force, displacement and strength, etc.) are displayed together with the mean values and test parameters.



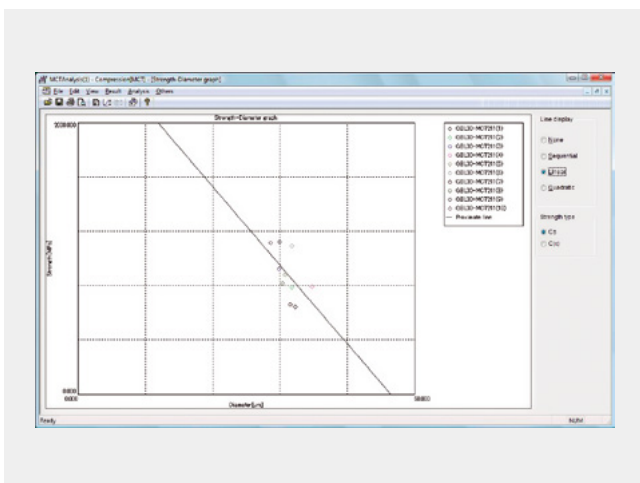
Superimposed Test Force - Displacement Curves

Differences in deformation characteristics of multiple specimens can be graphed for easy comparison by superimposing the test force - displacement curves. The curves can be plotted from the same point of origin.



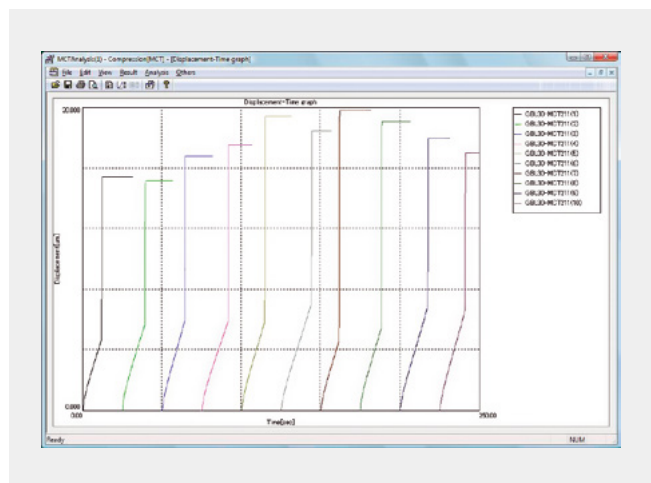
Strength - Particle Diameter Curve

The relationship between particle size and strength is displayed in a graph.



Displacement - Time Curves

These curves provide information about the deformation resistance the indenter receives from the specimen during deformation.

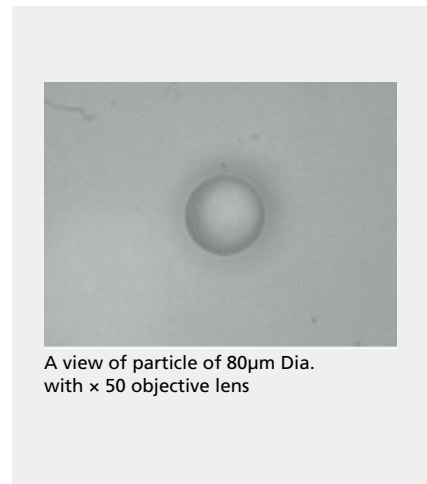
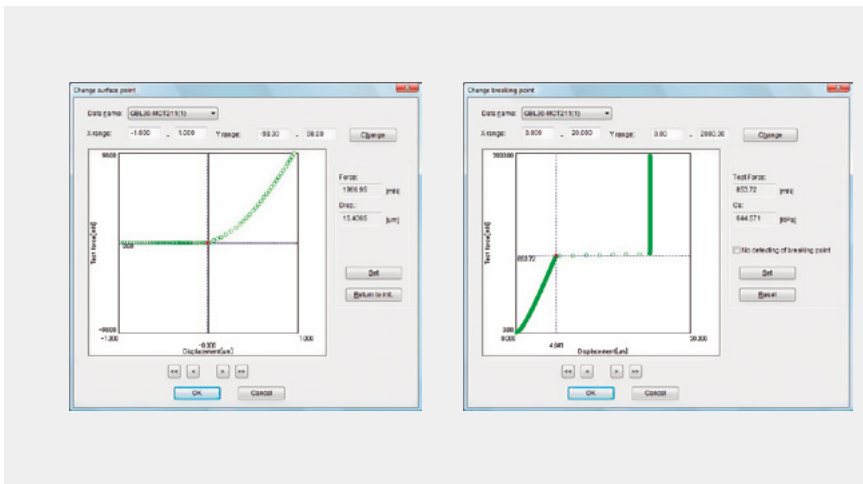


Checks and Changes for Surface Detection Point and Break Point

The surface detection point and break point - major influences on test results - can be checked and changed during analysis, as well as during testing.

Overhead Image Display on PC Screen

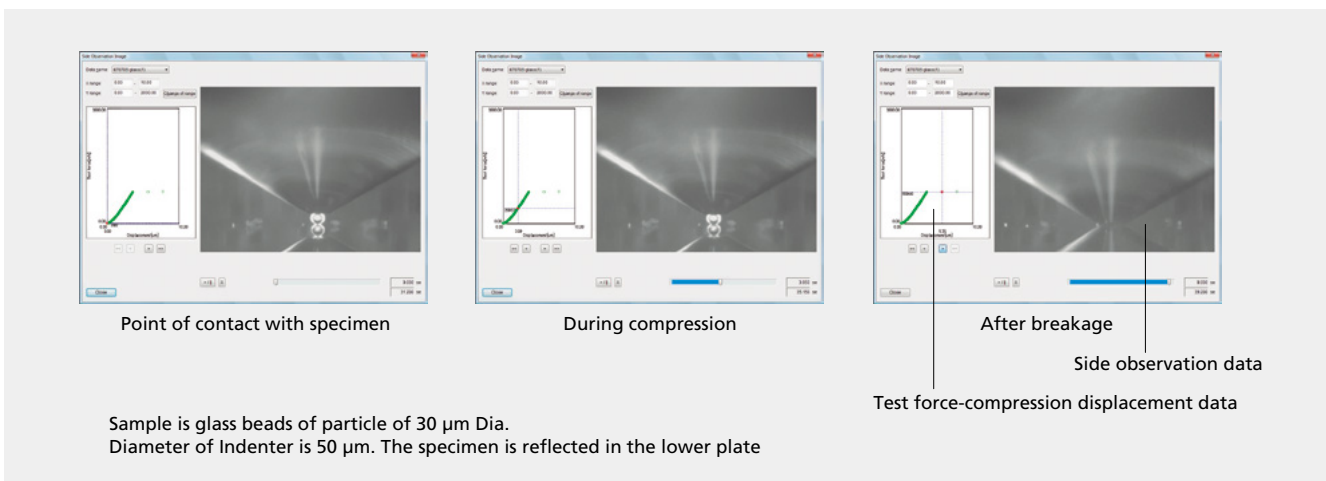
An overhead image of the specimen can be displayed on the PC screen (when the optional length measurement kit is used).



A view of particle of 80µm Dia. with x 50 objective lens

Image Observation During Compression test

The optional side observation kit allows monitoring the sample from the side direction during compression.



Sample is glass beads of particle of 30 µm Dia. Diameter of Indenter is 50 µm. The specimen is reflected in the lower plate

Specifications

	MCT Series			
	510	511	210	211
Loading unit				
Loading method	Electromagnetic force			
Loading range (mN)	9.8 – 4903		9.8 – 1961	
Load Accuracy	Within $\pm 1\%$ of displayed test force or 0.1 mN (whichever is greater)			
Resolution (μm)	5 (when testing at 49 mN or less)		2 (when testing at 19 mN or less)	
Displacement measurement unit				
Method	Differential transformer			
Measurement range (μm)	0 – 100	0 – 10	0 – 100	0 – 10
Min. increment (μm)	0.001	0.0001	0.001	0.0001
Linearity	Within $\pm 2\%$ of full scale			
Optical monitor				
Total magnification	Approx. $\times 100$, $\times 500$ ($\times 200$, $\times 400$, $\times 1000$ with option)			
Objective lens	$\times 10$, $\times 50$ ($\times 20$, $\times 40$, $\times 100$ with option)			
Eyepiece	$\times 10$			
Illumination method	Epiluminescent			
Illumination lamp	LED 3 W / 3 V			
Light path	Switching between observation and photography possible			
Optical Head				
Collimation method	Direct connection between encorder and control handle: synchronized movement of two indexes			
Detector	Optical encoder			
Effective measurement range	Approx. 200 μm (with $\times 50$ objective lens)			
Min. increment	0.01 μm / pulse			
Indenter				
Upper pressure indenter	Type: Flat indenter (50 μm diameter) (500 μm flat indenter as option) Material: Diamond			
Lower pressure plate	SKS flat plate (Diamond pressure plate available as option)			
Specimen stage				
Vertical positioning range	Approx. 60 mm			
Area	Approx. W 125 mm \times D 125 mm			
Horizontal positioning range	25 mm for both X and Y directions Min. increment: 0.01 mm (0.001 mm with option)			
Available test parameters				
Test mode	Compression test, load-unload test, cyclic test			
Shape of specimen	Particle, fiber or other shapes			
Data Processing Items				
	Calculation of compressive strength, display of test parameters and results			
	Display of test force and displacement data			
	Display of test force/displacement curve			
	Display of test force/displacement identification value			
	Display of strength/particle diameter curve			
	Display of displacement/time curve			
	Display of strength/parameter curve			
Power Supply	Single phase AC 100–115 V $\pm 10\%$, AC 230 V $\pm 10\%$ (Ground resistance 100 Ω max.)			
Utilities				
Power Consumption	Approx. 100 W (not including power consumption of PC)			
Grounding ^{*1}	The grounding pins of 3-pin connectors must be connected to a resistance of 100 W or less.			
Temperature	Recommended temperature: 23 $\pm 1^\circ\text{C}$ Allowable range: 10 $^\circ\text{C}$ to 35 $^\circ\text{C}$			
Vibration	Horizontal vibration: 0.017 Gal max. (at 10 Hz or more) 0.01 μm max. (at less than 10 Hz) Vertical vibration: 0.010 Gal max. (at 10 Hz or more) 0.005 μm max. (at less than 10 Hz)			
Humidity	80% max. (no condensation)			
Dimensions and Weight				
External Dimensions	Tester: Approx. W 355 \times D 405 \times H 530 mm Control unit: Approx. W 315 \times D 375 \times H 110 mm			
Weight	Tester: Approx. 60 kg Control unit: Approx. 5 kg			

*1 This product is a precision measuring device. Special consideration is required for the product's installation conditions.

Configuration

● Testing machine

Name	Q'ty
1. Testing machine main unit	1
2. Optical head	1
3. Objective lens ($\times 10$)	1
4. Objective lens ($\times 50$)	1
5. Flat indenter (50 μm diameter)	1
6. Specimen stage (X–Y stage)	1
7. Micrometer head	2
8. Thin specimen attachment, type 3	1
9. Lower compression plate	1

● Required PC Specifications

OS	Windows 7 (32/64 bit edition)
CPU	1 GHz min.
Disk Drives	CD-ROM drive
Display Resolution	1024 \times 768 min.
Expansion Bus	PCI Express $\times 1$, 2 slots min.

Installation precautions

Read the following precautions to aid selection of installation site.

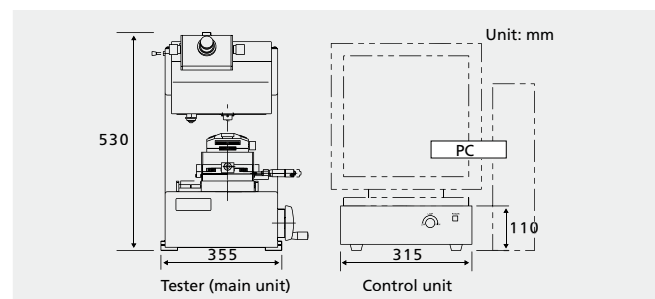
1. Avoid vibration

1. Select site with minimal floor vibration. In principle the testing machine should be installed on a shock-absorbing bench.
2. Avoid installing at sites with heavy human traffic.
3. Do not place the testing machine near devices that generate vibration.
4. If possible, do not install the testing machine on second floor or higher, as building may sway.
5. Install equipment away from roads and rail tracks.
6. Do not use the testing machine when equipment such as cranes are being operated.

2. Avoid air turbulence and sound

1. Keep the testing machine away from devices creating air turbulence such as air conditioners and make sure that air turbulence does not directly or indirectly come into contact with the testing machine.
2. Use a wind breaker when testing.
3. Do not open and close doors during testing.
4. Do not place the testing machine close to devices generating sound such as telephones.

External Dimensions



Optional Accessories

Length Measurement Kit (Color or Monochrome)

P/N for Length Measurement Kit, Color: 347-24778-46
 P/N for Length Measurement Kit, Monochrome: 347-24778-45

This kit enables easy positioning of the test point by displaying the image of the specimen and the size of the indenter on the PC screen. On-screen length measurement and image saving are also possible. Maximum magnification is $\times 2400$ (with 17-inch screen and $\times 50$ objective lens).



PC requirements :

It is possible to use with PC that our company separately recommends.

Side Observation Kit (Color or Monochrome)

P/N for Side Observation Kit, Color: 347-24779-16
 P/N for Side Observation Kit, Monochrome: 347-24779-15

This kit enables observation of specimen status during compression. The images are displayed on the PC screen and can be saved at any point in the operation. Maximum magnification is $\times 480$ (with 17-inch screen).



PC Requirements :

It is possible to use with PC that our company separately recommends.

Resistance Measurement Kit

P/N: 347-23105-XX (-11: 120 V -17: 220 V -18: 240 V)

This kit enables the acquisition of the correlation between the connection resistance and compression rate for conductive micro particles.

This kit comes with upper and lower pressure pads that are used as electrodes to measure electric resistance during compression testing.

PC Requirements :

RS-232C port (9-pin male D-sub)

It is possible to use with PC that our company separately recommends.

Micrometer Head (Digital Display)

P/N: 347-25447-12

This micrometer head digitally displays the shift of the specimen stage in the X and Y directions in an increment of $1 \mu\text{m}$ over a distance of up to 25 mm.

(The photo shows the micrometer heads attached to the stage.)



Desk-Type Vibration Absorbing Bench

P/N: 344-04193-06

A desk-type bench with coiled springs.

Active Vibration-Absorbing Bench

P/N 344-04211-11: AC 120 V
 P/N 344-04211-12: AC 230 V

This bench is used together with a special mount and performs active vibration absorption over a wide range, from 0.7 Hz to 100 Hz.

Objective Micrometer

P/N: 046-60201-02

Having a $10 \mu\text{m}$ increment scale, this device is used for microscope magnification alignment.

Objective Lenses

$\times 100$ objective lens P/N: 344-89977-40
 $\times 40$ objective lens P/N: 347-25400
 $\times 20$ objective lens P/N: 344-89924-40
 $\times 40$ extended operation lens P/N: 344-89300-41

(Enhances contrast in field of view.)

Diamond Lower Compression Plate

P/N: 5340-47050

This compression plate is used when testing extremely hard specimens.

Windbreak

P/N: 347-24400-01

This case reduces the effects of air vibration such as wind and sound.

W 700 \times D 600 \times H 750 mm

Flat Indenters

Cone indenters are available in the following flat-section diameters.

500 μm P/N: 340-47026-02
 200 μm P/N: 340-47026-04
 100 μm P/N: 340-47026-05
 20 μm P/N: 340-47026-06

Windbreak (Large type)

P/N: 347-24400-02

In the case that Active Vibration-Absorbing Bench is used this is select.

W 700 \times D 650 \times H 950 mm

Micro Compression Testing Machine with High-Temperature Unit

P/N: 347-24700-11 (50 Hz) P/N: 347-24700-12 (60 Hz)

Enables micro compression testing under the temperature of the actual environment



Configuration

1. Heater (1 unit)
 2. Temperature Controller (1 unit)
- High-Temperature Unit can be attached to MCT Series (510/511/210/211).

Main Specifications	
Heater	<ol style="list-style-type: none"> 1. Temperature setting range: (room temp. + 30°C) to 250°C (adjustable at 50°C or higher) 2. Accuracy: Within $\pm 2^\circ\text{C}$ of set temperature
Optical Monitor	<ol style="list-style-type: none"> 1. Total magnification of microscope: $\times 400$ 2. Objective lens: $\times 40$ 3. Eyepiece: $\times 10$
Micrometer Unit	<ol style="list-style-type: none"> 1. Collimation method: Synchronized movement of two indexes 2. Detector: Optical encoder 3. Effective measurement length: 250 μm (for length measurement with standard optical unit)
Utilities	<ol style="list-style-type: none"> 1. Power supply: 100 V 50/60 Hz 2. Power consumption: Approx. 1000 W 3. Installation space: Approx. W 2250 mm \times D 700 mm



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